Note Outline 24.1.1 – The Study of Light

I. Astronomy is very concerned with gathering and Studying light.

A. Most of our understanding of the universe comes from studying Starlight.

B. Visible light, the light we can detect with our eyes, makes up a small part of the different types of energy known as the Electromagnetic Spectrum.

II. Electromagnetic Radiation

A. Electromagnetic radiation includes:

Highly Dangerous:

i. Gamma Rays (Laser Eye Surgery)

ii. X-Rays (Skeletal Imaging)

iii. Ultra - Violet Rays (Sunburn)

Relatively safe:

iv. Visible Light (ROYGBIV)

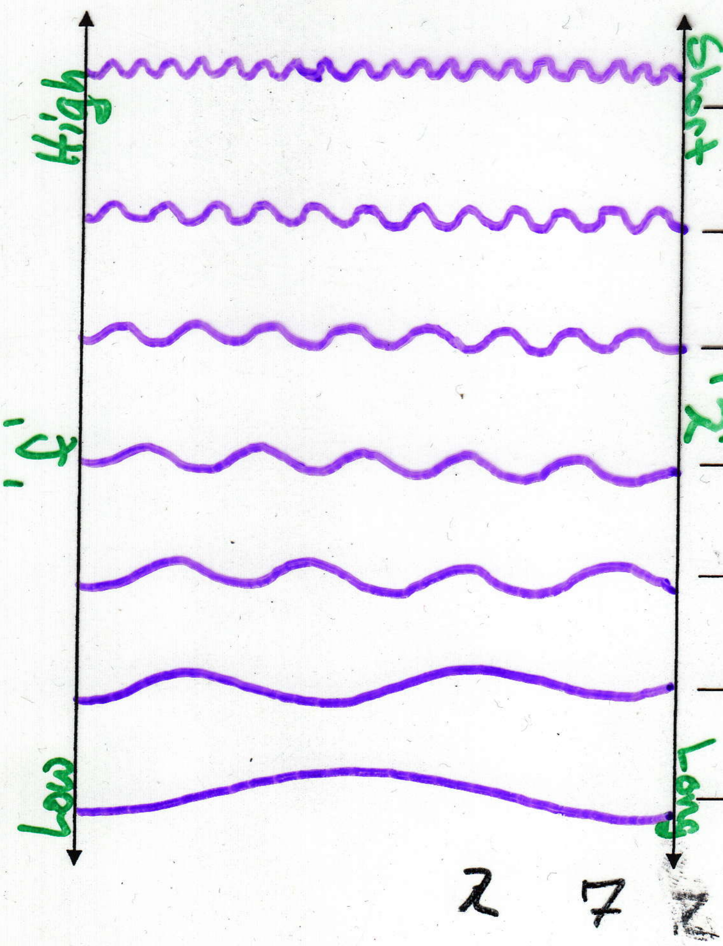
v. Infrared Radiation (Heat)

vi. Microwaves (Microwave Oven)

vii. Radio Waves (Communication)

B. Electromagnetic Spectrum:

f = frequency
λ = wave length



Gamma Rays

X-Rays

Ultra-Violet Rays

Visible Light (ROYGBIV)

Infrared Radiation

Microwaves

TV / Radio Waves

C. All EM energy, regardless of wavelength, travels through the vacuum of space at the 'speed of light' (c) = 300,000 km/s or 186,000 mi/s.

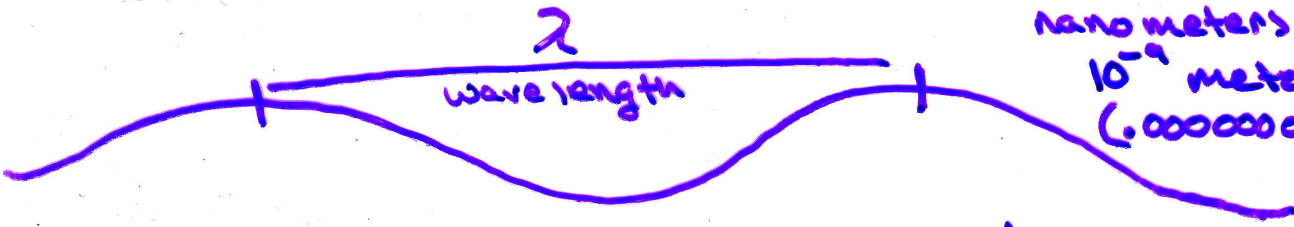
i. In ONE DAY (24hrs.), light travels ≈ 15,000,000,000 miles.

D. EM Radiation has properties of both a wave and a particle.

i. Wave Nature: EM radiation is a pattern of oscillating (alternating) electric and magnetic fields.

a. Wavelength (λ): The length between successive wave crests. See diagram below:

* λ measured in nanometers (nm) 10^{-9} meters (.000000001 m)



b. Frequency (f): The number of waves passing in 1sec. Measured in Hertz (Hz). 1Hz = 1 wave/second.

c. fλ = c, thus:

C = Speed of light

f = c/λ

λ = c/f

d. λ is inversely proportional to f.

ii. Particle Nature: a "light" beam can be thought of as a stream of tiny, massless energy packets called Photons.

a. Photons can be thought of as extremely small bullets fired from a machine gun.

b. Photons can push on matter with a force called radiation pressure. (ex. Comet tails point away from the sun due to this force).

c. Short λ = more energetic photons.

E_{photon} is inversely proportional to λ.

$$E_{photon} \propto \frac{1}{\lambda}$$

Note Outline 24.1.2 – Study of Light Continued

III. Spectrosopy/Spectral Analysis

A. Defined as the study of the properties of light that depend on wavelength (λ), or the spectral analysis of the 3 types of spectra.

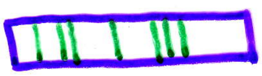
B. Continuous Spectrum: produced by an incandescent solid, liquid or gas under high pressure. Appears as an uninterrupted band of color (rainbow).

i. incandescent = "to emit light when hot", not all substances behave incandescently.

C. Absorption Spectrum: produced when visible light (usually from a star) is passed through a relatively cool gas under low pressure. The gas absorbs selected λ's of light. Appears as a band of color with dark lines.

dark line spectra

D. Emission Spectrum: produced by a hot gas under low pressure. Appears as a series of bright lines of particular λ's depending on the gas that produces them.


bright line spectra

E. Most stars' spectra are absorption or "dark-line" spectra.

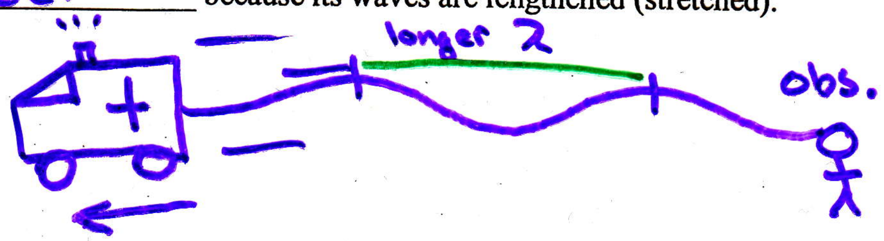
i. Each element or compound produces a unique set of spectral lines.

ii. The unique spectra of different elements/compounds can be used to identify a star's Chemical composition - like a finger print.

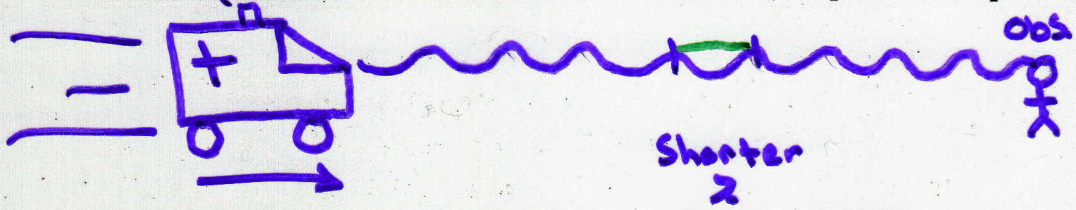
IV. Doppler Effect

A. The perceived change in wavelength of a sound/light wave that is emitted from a source moving away or toward an observer.

B. Visible light from a source moving away from an observer appears "redder" because its waves are lengthened (stretched).



C. Visible light from a source moving toward an observer appears "bluer" because its waves are shortened (compressed or squished).



D. The amount of red or blue shift is related to the rate of movement of the source (how fast its moving toward or away from the observer).

i. Larger shifts = faster rates of movement

ii. Smaller shifts = slower rates of movement

E. The Doppler Effect is used to determine whether a star or other celestial body is moving away from or towards Earth.

F. The Doppler Effect & Spectral Analysis can be ~~concluded~~ used to calculate the velocity (V) of a moving light source.

i. Doppler Formula

$$V = \frac{c \Delta \lambda}{\lambda}$$

(Low value → λ)

c: 3×10^5 km/s

λ: nm

Δ: change

* Does not tell you direction, only velocity.